

DTE-LDC 1-1

Request:

Under the existing Service Quality Guidelines, each electric distribution company reports line losses. For example, MECo reports line loss in terms of energy losses for its entire system on a monthly basis. Please provide peak megawatt ("MW") loss separately at each voltage level, such as 345 kV to 120/240 kV, and calculate as a percentage of your annual system peak. Also, calculate total system peak MW loss as a percentage of system peak. In addition, please provide the method used to calculate these losses.

Response:

To provide the values requested, a utility would have to have demand meters installed at each voltage transition, synchronized to record at precise time intervals. This would be very costly, and would provide very little if any actionable or beneficial information. Accordingly, the Company does not have such capability.

Prepared by or under the supervision of: James D. Bouford

DTE-LDC 1-2

Request:

Refer to the Initial Comments of Massachusetts Electric Company and Nantucket Electric Company ("MECo") at 15-16, Att. 1, where MECo discusses discrepancies between indices collected using paper-based outage data collection systems versus mature/automated outage data collection and management systems. Please indicate:

- a) whether this type of discrepancy applies to your company's outage data collection and management systems; and
- b) whether the existing fixed SAIDI and SAIFI benchmarks are a true representation of your company's historical performance, and whether these existing benchmarks should be revised. If so, also propose new benchmarks.

Response:

- a) Yes, this discrepancy does exist within the reliability data collection processes of the past.
- b) The existing SAIDI and SAIFI benchmarks are not a true representation of the Company's historical reliability performance for three reasons.
  - 1) The Company introduced a new computerized outage management and data collection system in 1999. This system replaced a manual method of collecting the outage reports that was dependent upon the memories of operating personnel, who were often working in times of great stress, and the ability of a piece of paper to be handled by many people without being misplaced, lost, or destroyed before the data could be inputted to the system. This new outage management system also directly utilized customer count data from the Company's computerized customer service system, thereby more accurately identifying the number of customers affected by each outage. The improved accuracy of data collection, and the more precise determination of customer counts, has caused an increase in the reliability metrics after the introduction of the new computerized system.

Attached is a paper, pending publication, entitled "Incrementing Averages, a Methodology for showing the Impact of OMS Addition on Reliability Indices", that presents a method to determine the effect on the reliability metrics by the introduction of a new data collection system.

DTE-LDC 1-2 (continued)

- 2) The SAIDI and SAIFI benchmarks were determined based upon the premise that the probability of an annual system reliability metric would be equally distributed around the mean value of the data population. It has been shown through the work of the IEEE Working Group on Distribution System Design that this is not the case. The population of system reliability data is not distributed in a Gaussian manner, or not normally distributed in the manner of the familiar bell-shaped curve. It can be shown that the probability of reliability metric values above the mean is greater than the probability of those below the mean.

Therefore, the existing benchmarks unfairly penalize the normal variability of a company's reliability by making it easier to exceed the penalty benchmark.

- 3) The existing benchmarks are based on historical reliability results that allow the exclusion of such things as distribution transformer outages and outages of services and secondaries. These exclusions distort the actual reliability results experienced by the customers. In addition, the definition of major events, which also can be excluded from the reliability results, was changed to a level that is nearly impossible for any large, dispersed system to reach. This greatly distorts the year-to-year values of the reliability metrics and causes the benchmarks to be driven to a large degree by those events beyond the control of the utility.

The Company has developed a set of proposed benchmarks that adjusts for the three previously mentioned anomalies. Specifically, the early historical reliability data (for 1997 and 1998) has been adjusted to reflect the transition in 1999 to a computer based outage data collection system. In addition, the benchmarks (i.e., triggers for penalties and incentives) have been calculated using IEEE 1366-2003 methodology, including the definition of Major Event Days and the use of logarithmic values of annual reliability performance to reflect the lognormal distribution of reliability data (see pp. 16 - 25 of the Company's initial comments in this docket). The targets have been set recognizing the log-normal nature of reliability data by determining the minimum and maximum penalties in log-space. Finally, transformer outages and outages of services and secondaries that affected more than one customer have been included in the reliability data to more accurately reflect actual customer reliability. Shown below is a table of historical performance for 1997 through 2004 consistent with the above methodology, along with the proposed 2005 benchmarks.

Index	1997	1998	1999	2000	2001	2002	2003	2004
SAIDI IEEE Adj	80.84	86.41	79.13	82.3	95.73	117.01	100.07	122.24
SAIFI IEEE Adj	1.15	1.20	1.218	1.196	1.242	1.456	1.384	1.408

Massachusetts Electric Company  
Nantucket Electric Company  
Docket DTE 04-116  
Responses to Set B of the Department's First Set of Information Requests

DTE-LDC 1-2 (continued)

The proposed 2005 benchmarks are shown in the tables below:

	SAIDI
Max Incentive	67.32
Min Incentive	79.66
Mean SAIDI	94.26
Min Penalty	111.54
Max Penalty	131.99

	SAIFI
Max Incentive	1.07
Min Incentive	1.17
Mean SAIFI	1.28
Min Penalty	1.40
Max Penalty	1.53

Prepared by or under the supervision of: Cheryl A. Warren

# Incrementing Averages, a Methodology for showing the Impact of OMS Addition on Reliability Indices

*James D. Bouford and Cheryl A. Warren, Senior Members*

**Abstract**—Since performance based rate making began in earnest in the 1990's, a method to identify the impact of changing to a new outage management system (OMS) on reliability indices has been sought. As companies become more sophisticated in their data collection and data processing efforts, using new systems and different processes has resulted in more accurate resulting metrics, often leading to a perceived worsening of the company's reliability performance. In addition, there is the underlying concern that new rate structures will provide incentives to companies to perform less maintenance. This paper will present a novel approach to determining the impact of system changes, whether a new OMS or maintenance strategy, on reliability indices. In doing so, it will show both the impact of system changes as well as degradation in performance, if either, or both are present.

**Index Terms**—distribution reliability, outage management systems, impact on indices.

## I. INTRODUCTION

The advent of deregulation and performance based rates has coincided with many utilities introducing new, more sophisticated and more accurate outage management systems. The introduction of these programs and systems at the same time has clouded the interpretation of changes in the reported reliability metrics of the utilities. Advocates have argued that the new rate structures provide an incentive to reduce maintenance and allow the system to deteriorate. Utilities point to the more accurate data collection capability of the OMS. Others suggest a changing continental weather pattern as a cause. This paper will hypothesize a set of premises and develop a methodology for showing the impact of change on reliability performance.

The hypotheses are that:

1. The introduction of a new interruption data collection system will allow for the more accurate collection of interruption event data, including the number of events, the number of customers interrupted (CI) per event, and the customer minutes of interruption (CMI) per event.

A. No events could be "lost in the shuffle of paper records," affecting the CI and the CMI.

B. Switching actions during a single event would be recorded correctly, affecting the CI and the CMI.

C. Reports could be matched to dispatch records, affecting the CI and the CMI.

2. The reliability metrics will experience a definite, identifiable and measurable quantum increase after introduction of the OMS.

3. When a quantum increase occurs in a serial data set, so that the average for the data after the increase is significantly different than that prior to the increase, two distinct groupings will appear when incrementing averages are applied.

4. The magnitude of the increase in the resultant metric value can be determined by the percent difference between the averages of these two groupings of incrementing averages.

5. When the values in the years affected by the introduction of the new data collection system are reduced by the percentage difference of the averages of the two groupings, any other factor affecting the increase will be shown in the plotting of the incrementing averages.

6. The method will also clearly show not only the impact of changed processes/systems but also any system deterioration affects. These may be due in part to weather.

## II. BACKGROUND

A review of one company's data prompted this analysis. The data is presented in Table 1 below.

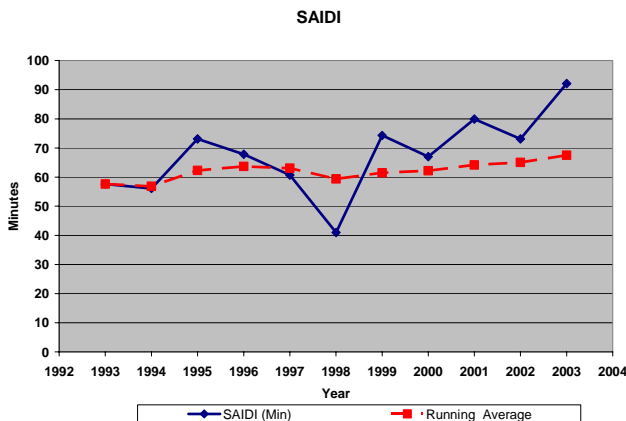
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**Table 1 Yearly SAIDI & Running Averages**

Year	SAIDI (Min)	Running Average
1993	57.6	57.6
1994	56.1	56.9
1995	73.1	62.3
1996	67.8	63.7
1997	60.7	63.1
1998	41	59.4
1999	74.3	61.5
2000	67	62.2
2001	79.9	64.2
2002	73.1	65.1
2003	92.1	67.5

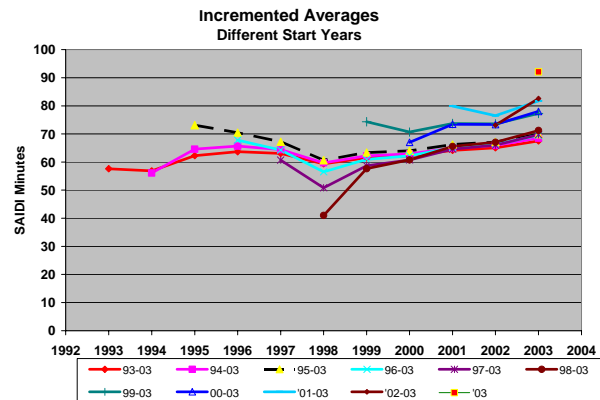
Plotting either the yearly SAIDI values or the running average will show that the reliability for this Company has deteriorated over time, as shown in Figure 1.



**Figure 1 Actual SAIDI Values & Running Average**

What isn't obvious is any change that might have occurred in the data set, any factor that causes a step increase in the values after some specific occurrence. This sort of change is what might be expected in reliability metrics when a new outage management system is introduced. When a new system is introduced, processes, policies and procedures change with it, often leading to greater reporting accuracy and a perceived worsening of reliability performance.

Rather than a simple running average, a method of incrementing averages is applied to the data. This is done by incrementing the start year for a series of running averages of the SAIDI values. Figure 2 shows the results for the subject data set.



**Figure 2 Incrementing Averages Applied to Data**

Each data point on a specific line represents the average from the start year of that line to the year represented by that data point. For example, on the dotted black line, the first point is the SAIDI for 1995, while the fourth point is the average from 1995 to 1998. For the years pre-1999, the incrementing averages "track" towards the same value range through 1999, approximately 60 minutes. Even the incrementing averages starting in 1996, 1997, and 1998, which are greatly affected by the outlier value of 1998, trend towards the average of the 1993 – 1998 data set. This can be seen as a grouping of the averages at the 1999 point.

The incrementing averages for post-1998 start years are demonstrating a marked difference in value; they are "tracking" towards a very different value range than the pre-1999 values. For the subject utility, an OMS was implemented in 1999. What is being shown by this action of the incrementing averages is that the post-1998 data set has a different, and higher, average value than the pre-1999 data set. It appears that the introduction of the OMS has caused the SAIDI values to be higher by some rather constant amount. The two distinct data sets have established separate groupings of their incrementing averages for this evaluation period. If the incrementing averages were carried forward for enough years, all the incrementing averages would merge to the average of the complete single data set, but, any incremental change that occurs will cause a new grouping to appear. Reviewing the subject data set in Figure 2 seems to show that a step-change in metrics occurred in 1999. The percent increase of the reliability metrics due to implementing the new OMS system can be determined.

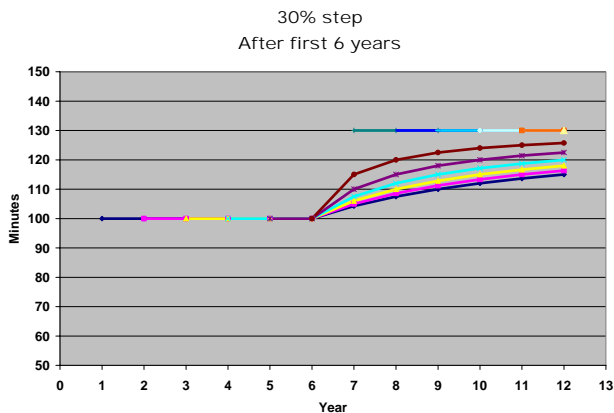
What is not so obvious in Figure 2 is that only five years are required for the incrementing average to reach the approximate average of the data set. For example, beginning with the incrementing average that starts in 1993 in Figure 2, the fifth data point gets that "track" to between 63 and 65, the "middle" of the accumulated incrementing averages to that point. To emphasize this, the incrementing average that starts in 1998, the "outlier," gets back to the group average by

2002, in five years. This appears to hold for each set of incrementing averages for all the various companies reviewed.

What can also be seen in Figure 2 is that “outlier” values, such as the very low value for 1998, will produce a short-term distortion to the incrementing average track of the immediately preceding values. This can be seen in the tracks for 1996 and 1997 in Figure 2. The first few values of the tracks for these years are lowered from the group average. More important, however, is that even these incrementing average tracks adjust to the group average after five years.

### III. INCREMENTAL CHANGES

From the above, it is clear that an incremental change to the data will be seen as a new grouping of the incremental averages, after the introduction of that change. To drive the point home further, consider an experimental data set with a base SAIDI of 100 minutes. For the first 6 years, the SAIDI value is constant at 100 minutes. Starting in year 7, a step increase of 30 minutes is added to the base of 100 minutes, and for years 7 through 12; a value of 130 minutes is maintained. Using this hypothetical data will show the expected result of a step change in performance. Figure 3, below, shows this data graphically.



**Figure 3 Step Change Example**

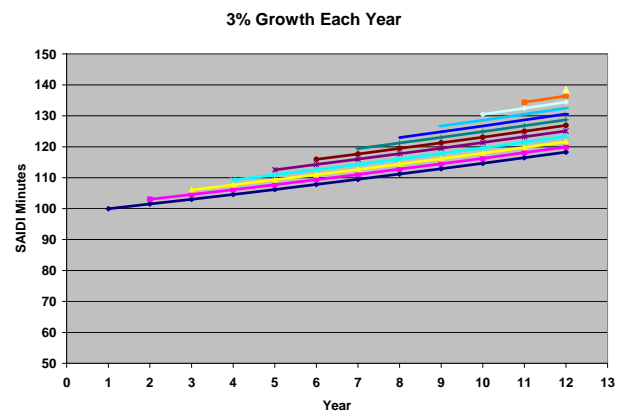
When an incremental change in the average of the data values occurs, a fanning pattern of the incrementing averages, just prior to the change, is seen. This fanning of the incrementing averages is a characteristic of an incremental change in the data set. Also note that the incrementing averages of the post-6-year data are averaging 130, showing the 30% increase, and that the incrementing averages of the pre-7-year data are adjusting to the new average of the complete data set

In Figure 2, this fanning due to an incremental increase can be seen in the incrementing average tracks

between 1998 and 1999. Since the value in 1998 is much lower than the group average, the fanning appears to be focusing the values towards the 1999 value. If the 1998 value were approximately equal to, or higher than the group average, the fanning would show a spreading out of the values towards 1999.

### IV. CONSTANT GROWTH

An incremental change has been shown to cause a new grouping of the incrementing averages after that change occurs; along with a fanning pattern of the tracks at the time of the incremental change. A constant yearly growth rate, however, creates a different and very distinct pattern with incrementing averages; a series of sloping parallel lines for those years experiencing growth. This is seen in Figure 4 which shows a hypothetical dataset created to illustrate the point. In Figure 3 a constant 3% growth rate is applied to the yearly SAIDI values. No “grouping” of results occurs. This pattern is easily identified within any particular data set when constant change occurs, even over just a portion of the complete data set.



**Figure 4 Incrementing Averages with Constant Growth**

### V. CALCULATION OF IMPACT

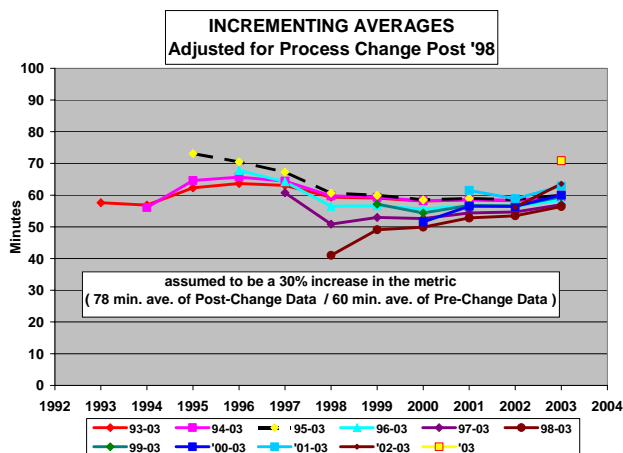
Figure 2 will be used to show how the actual percent change in the reliability metric, due to the introduction of an OMS, or any other process, can be determined. It is necessary to have at least five years of data prior to, and after the incremental change to effectively utilize this method.

Once the initiation of an incremental change has been determined, through the indication of a new grouping of the incrementing averages and the tell-tale fanning of the tracks, the post-change values are reduced by a derived percentage. This percentage is determined by the ratio of the average of the post-change incrementing averages to the average of the pre-change incrementing averages. In Figure 2, the incremental change has obviously occurred in 1999.

The average of the pre-change incrementing averages in Figure 2 can be found at the location where the tracks with at least five data points are in the year prior to the change, in this case 1998. Two tracks, '93-'03 and '94-'03 fit the criteria, and their values in 1998 are approximately 60 minutes. It is a fortunate coincidence that the '95-'03 track also falls at this value, lending a degree of certainty to this average. As noted above, the other tracks, '96-'03 and '97-'03, are distorted for the few years prior to 1998 by the outlier SAIDI value in 1998. In every case evaluated by the authors, the average of the pre-change incrementing averages can be determined in this manner.

The average of the post-change incrementing averages requires one of two different approaches. If there is a trending of these tracks towards the end point of those with five or more years of data, and a general grouping of the tracks exists, other than the effects of obvious outliers, then the average of the post-change incrementing averages will be the average value of those tracks with five or more years of data. In Figure 2, the post-1998 incrementing averages appear to fit this criterion, therefore, the average of the post-change incrementing averages is the value of the '99-'03 track at 2003, or 78 minutes. Again, it is a fortunate coincidence that the '00-'03 track also falls at this value, while the later tracks are influenced by the outlier value in '03.

The percent change in the reliability metric, due to an incremental change in the process, can now be calculated from the ratio of 78 minutes to 60 minutes, or 30% for this example in Figure 2. The value of this method can now be shown graphically by reducing each metric value after the incremental change by the derived percent and plotting the result. This is shown in Figure 5.



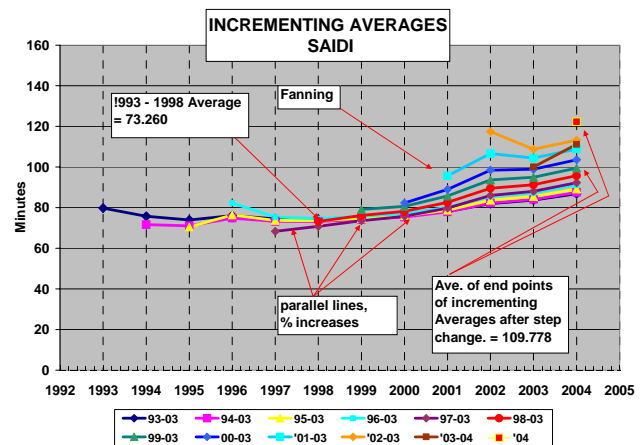
**Figure 5 Verifying Change Amount**

Reflecting a 30% change in the post '98 metric values, due to a process change such as the implementation

of an OMS by this Company, causes all of the incrementing averages to more closely track to the same average value as determined for the pre-change incrementing averages, Approximately 60 minutes. In effect, if the process change had not produced a 30% increase in the post-change metrics, a single grouping of the incrementing averages would have occurred and the average of the data set would have remained at 60 minutes.

The post '00 values appear to be tracking to a higher level than the 60 minute average, after adjustment, due to the 2003 "outlier" value. A similar, but reverse, effect can be seen in the tracks of the earlier year's data after the very low 1998 value.

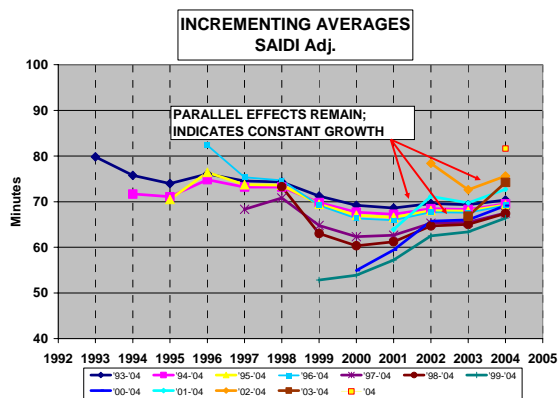
The second approach of dealing with finding the average of the post-change incrementing averages requires the use of a different Company's data set. These data are shown in Figure 6.



**Figure 6 Step Change with Growth Example**

As noted in Figure 6, this set of incrementing averages includes both an incremental change starting in 1998, noted by the change in the grouping of the tracks, and a constant growth impact, noted by the parallel tracks. The post-change tracks are not trending towards the ending value of those tracks with five or more data points. Therefore, the average of the post-change incrementing averages must be determined by taking the average of the end values of the post-change tracks, or 109.778 minutes in this case. The average of the pre-change incrementing averages is determined as above, and is 73.260 minutes.

If the percent change in reliability metrics were applied as in the previous example, in this case a 49.8% reduction of post 1998 values, the resultant graph visually shows that this single effect does not represent the changes taking place. This is shown in Figure 7.

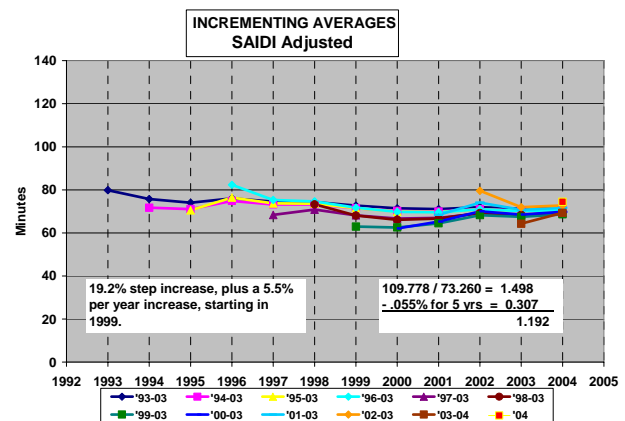


**Figure 7 % Adjustment with Growth Present**

However, not only do the incrementing average tracks not group to a common set, the parallel tracks, indicative of a constant yearly growth rate in the metric, are still present. This leads one to conclude that there are both an incremental change and a constant growth factor affecting these data.

The proper way to identify the change in the reliability metrics is to apply both an incremental percent change and a growth rate to the post-change data values. This is done by using heuristic iteration, which involves choosing a reasonable percent increase, subtracting that impact from the incremental change calculated previously, and viewing the resultant graph of the incrementing averages. One can quickly determine the most appropriate value to use for the growth rate; it is when the tracks group together and trend to the same data set average value for the pre-change metrics.

As seen in Figure 8, a growth rate of 5.5% per year, in addition to an incremental change of 19.2%, causes the incrementing averages to tightly group, with no parallel tracks remaining, and trend towards the 73.26 average value of the pre-change metrics. This Company not only had a change in its reliability metrics when an OMS was installed in 1999, there has been a steady deterioration of the reliability metric since that time. A possibility for this effect is the increasing ability of the users to improve on the data accuracy by utilizing the new system. Or, performance could just be deteriorating.



**Figure 8 Post Adjustment Averages**

## VI. SUMMARY

The incrementing averages method outlined in this paper provides an approach to quantifying the impact of the addition of a new OMS and associated processes to reliability indices. It separates the data into two components, if two exist: incremental change, indicating a process change with a one-time effect, and constant growth, indicating a program change with yearly impact, thereby allowing utilities and regulators to understand the whole reliability picture.

## VII. REFERENCES

1. IEEE Std. 1366-2003, Guide on Electric Power Distribution Reliability Indices.
2. "Managing Changes in Reliability Indices After OMS Implementation" presented at the T&D Conference in Dallas Texas, September 2003 and in the conference proceedings.

## VIII. BIOGRAPHIES

**James D. Bouford P.E. (SM'01')** received a B. Sc. (1968) in Electrical Engineering from University of Maine in Orono, ME and an M. Mgt. (1980) from Thomas College in Waterville, ME. Mr. Bouford worked for Central Maine Power from 1968 –



1999 where he held numerous positions. Today, he is the V.P. of Engineering Services for National Grid USA Service Company, Inc., based in Northborough, MA 01532. Mr. Bouford is the recipient of two EPRI Innovator Awards (1992 and 1993). He also chaired the EPRI Task Force on Custom Power (1993) and the EPRI Task Force on Distribution (1991-1993). Mr. Bouford has authored and co-authored several technical papers, spoken at several conferences and chaired a national conference on optimizing

distribution reliability. He is an active member of the IEEE where he has chaired the Task Force on Reliable Distribution Design and is a member of the WG on System Design. He is a principal author of the Major Event definition for IEEE 1366.

**Cheryl A. Warren** (S'85-M'87-SM'99) received her B.Sc. (1987) in Electrical Engineering and M.Sc. (1990) in Engineering from Union College in Schenectady, NY. She has been employed by Central Hudson Gas and Electric Company in Poughkeepsie, NY, Power Technologies, Inc./Stone and Webster in Schenectady, NY, and Navigant Consulting, Inc in Albany, NY. She now works for National Grid USA Service Company, Inc., based in Albany, NY as the manager of T&D Systems Engineering. Her main areas of expertise are distribution reliability analysis, power quality; GIS/OMS and enterprise wide IT systems integration. Mrs. Warren has authored and co-authored twenty-seven technical papers and spoken at numerous conferences. She chairs the IEEE Working Group on System Design that wrote the *Guide on Electric Power Distribution Reliability Indices* IEEE Std. 1366-2003. She is also the IEEE PES Awards and Recognition Chair.

